



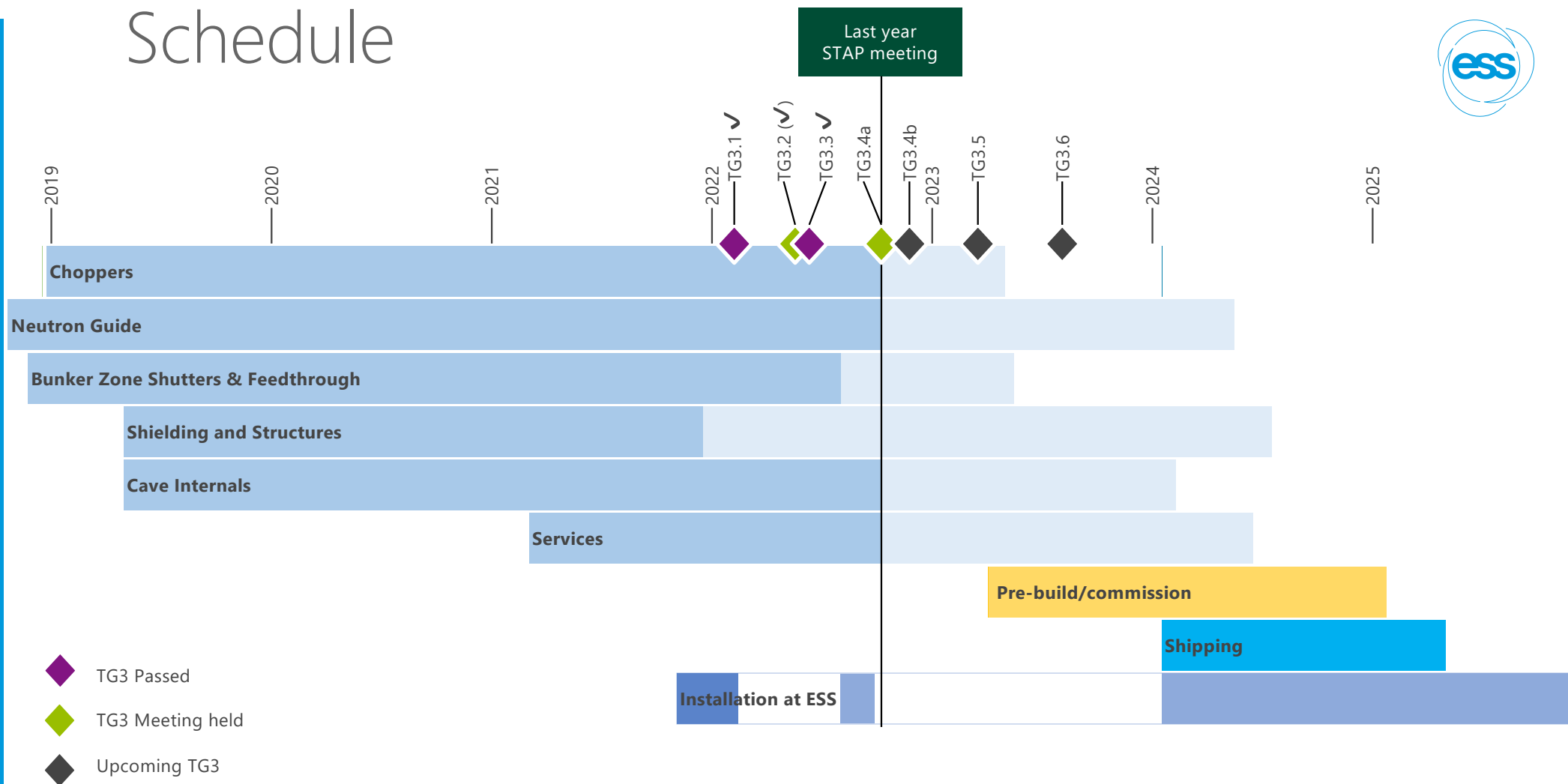
FREIA Project Update

Reflectometry STAP

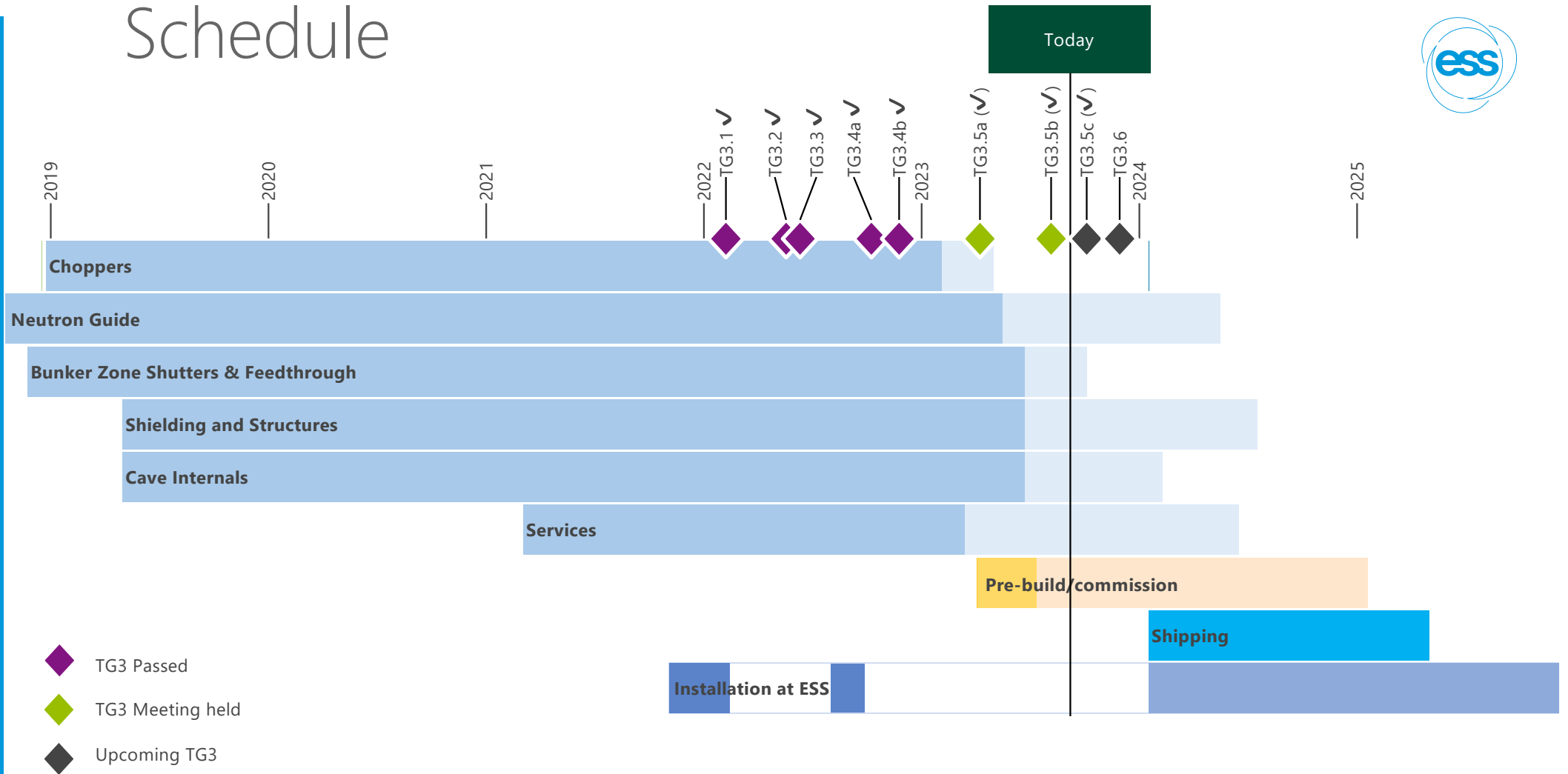
PRESENTED BY TOM ARNOLD

2023-09-18

Schedule



Schedule



FREIA Status

WFM Choppers

- Quality issues continue
- Spindles returned to SKF – rework underway
- Discs to be returned to Airbus

Collimation System

- Collimation vessel delivered to STFC
- Collimation translation stages ready for assembly
- Kinetics slits and window manufacture underway
- Guides and support structure designs complete
- Design effort ramping up on remaining components of the collimation system



Bunker Modules

- Manufacture underway

Detector Bench

- Manufacturing drawings complete
- Welded components in manufacture
- Remaining components ordered or out for quote

Heavy Shutter

- TG3 review pending
- ESS evaluating material selection for fire compatibility

Bunker Wall Feedthrough

- Shielding insert and alignment devices delivered to ESS
- Guide components to be delivered in Oct.
- ESS Crane repairs preventing installation

WBC chopper discs

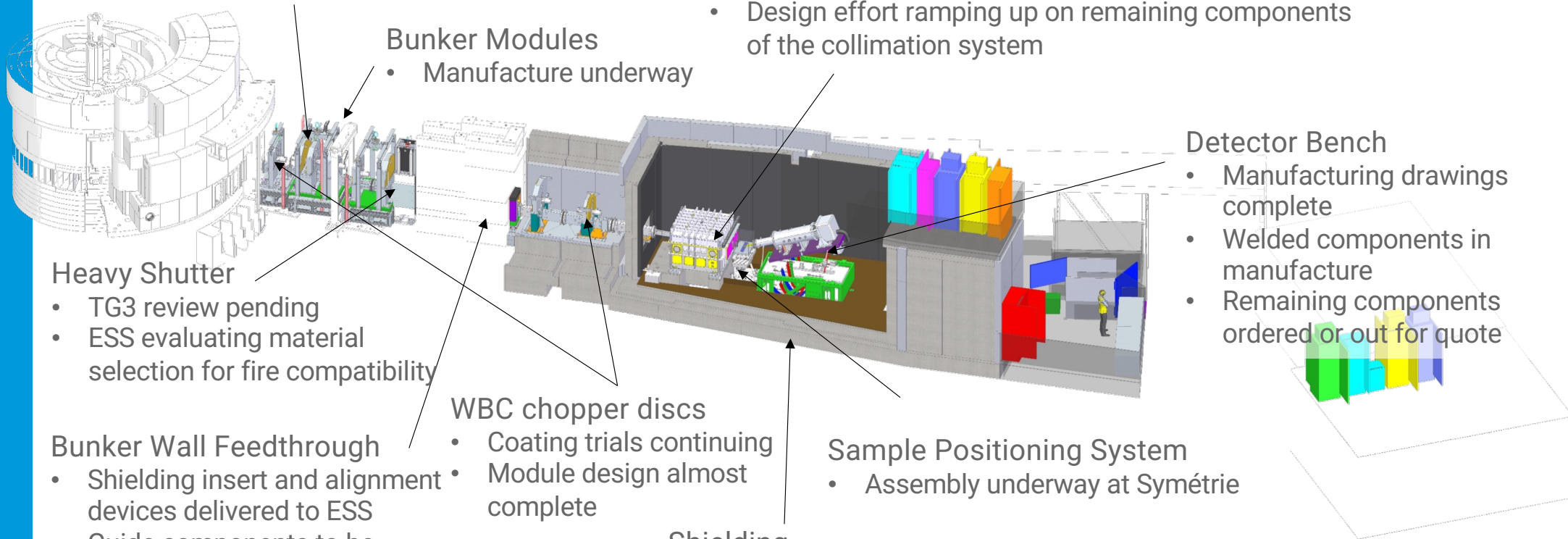
- Coating trials continuing
- Module design almost complete

Sample Positioning System

- Assembly underway at Symétrie

Shielding

- Detailed engineering design in progress
- Neutronics contract underway at UKAEA



Chopper Commissioning

Initial testing of the three 56Hz chopper assemblies identified quality issues with both the Airbus carbon-fibre chopper discs, and SKF spindles.

It has been challenging to achieve a good balance on some discs, especially on discs where a substantial proportion of the balancing holes were already filled during manufacture. Additionally, one of the balancing inserts has become loose.

Excessive vibrations were observed near operating speed, which has been identified to be predominantly due to a poor fit between the discs and the SKF spindles causing a massive imbalance in the system. Metrology has confirmed that this is due to non-conformities in the spindle machining.

A further test using a well-matched showed resonances in the disc near to operating speed are also contributing.

The spindles have been returned to SKF for replacement shafts to be fitted. The 1.3m discs will be returned to Airbus for rework.



Disc Summary



| | Status | Next steps |
|--------------------|---|---|
| WFM1 (56Hz) | Estimated 54g of additional weight are needed to balance, but no balancing holes available. Operated to 20Hz, with a resonance at 16Hz | Return to Airbus. Re-balance using CF/epoxy to free up balancing holes. Check balancing insert bonding. |
| WFM2 (56Hz) | Fine balancing carried out. Operated at 56Hz, vibration borderline acceptable. Resonances at 16Hz & 53Hz. | Airbus/ISIS to check balancing insert bonding. |
| FOC1 (56Hz) | Balancing insert came loose. Hub/spindle fit out of tolerance. Operated to 20Hz, with a resonance at 15Hz. | Return to Airbus. Re-attach loose insert. Check bonding of other inserts. |
| WBC2 (14Hz) | Disc rebalanced on ISIS balancing machine – 5g added. | Disc to remain at ISIS. ISIS to check balancing insert bonding. |
| FOC2 (42Hz) | Untested due to similarity with other 1.3m discs. | Airbus/ISIS to check balancing insert bonding. |
| FOC3 (28Hz) | | |

Chopper Commissioning –Way Forward

Plan A – Rework current chopper system

- Repair spindles and discs
- Attempt finer balance and better tuning
- Accept higher vibration levels?

Plan B – Change spindles to rolling-element

- Stiffer spindles should increase resonant frequencies beyond operating speeds
- Significant rework of housings to incorporate new spindles

Plan C – Stiffen discs

- Stiffen discs and hubs by adding material
- Further work needed to characterise resonances and possible modifications

Plan D – Redesign chopper system for 42Hz

- Keep existing spindles and housings, replace discs
- Compromise wavelength resolution

Plan E – Rainbows

- Alternative method for finer wavelength resolution requires substantial design effort
- Change to detector resolution required

Bunker Modules Procurement

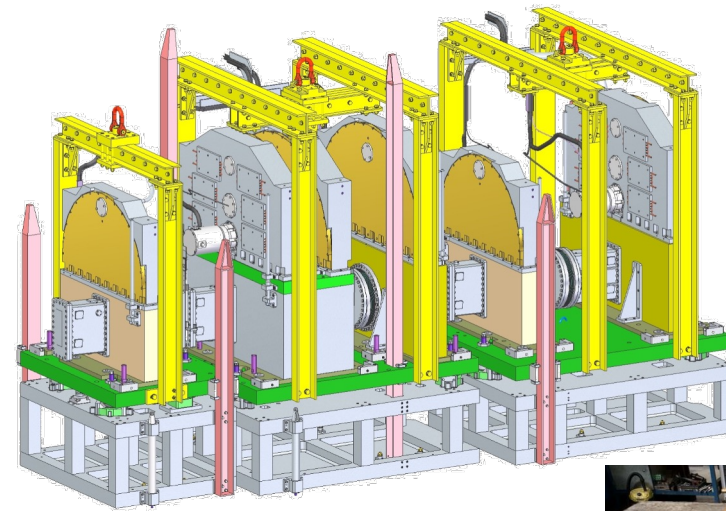
Procurement of the bunker modules is being undertaken in a phased manner, with multiple tender exercises.

Components have been grouped according to size and manufacturing process in order to streamline the manufacture process.

The contract for the large vacuum housings has been awarded. Due to material size limits, knife-edge seals were re-evaluated using 5000 series Aluminium instead of 6000 series with acceptable test results.

The lifting frames have been tested and delivered to STFC ready for pre-building of the modules.

Module 1 Module 2 Module 3



WBC Choppers & Out of Bunker Modules



Aluminium WBC choppers have had issues with preparation of absorbing coatings - some distortion of the test plate due to shrinkage.

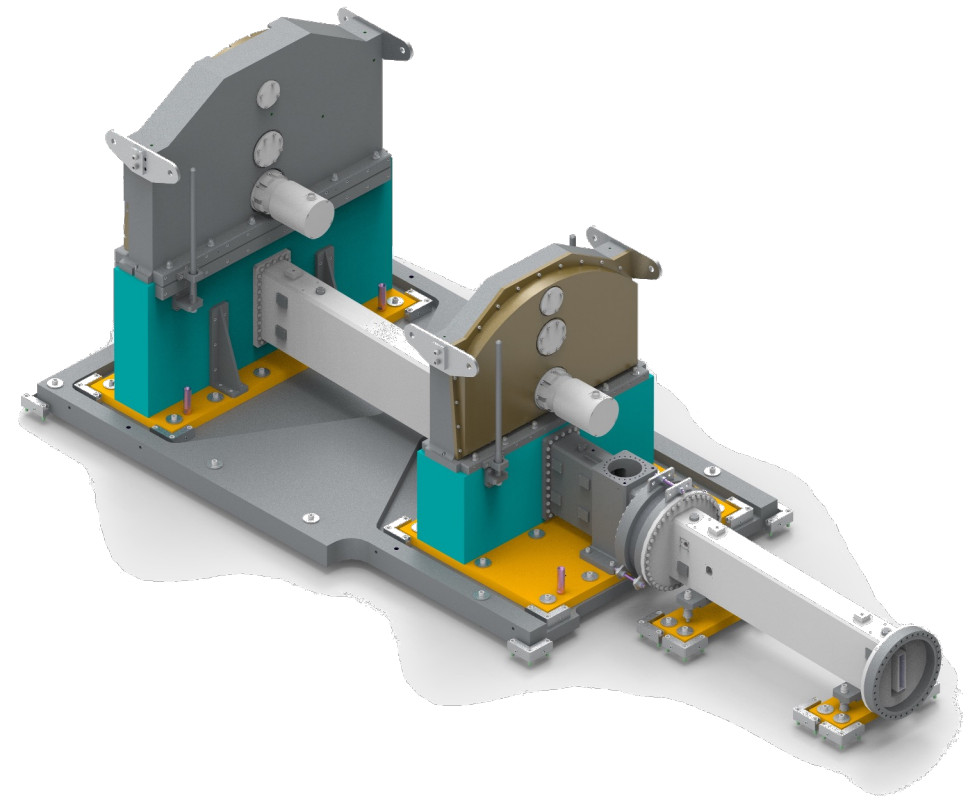
A range of preparation methods have been tested including with the addition of carbon fibre to stabilise the coating. None of these methods have successfully removed the distortions

Cost to change over to carbon-fibre discs has been evaluated – this is not feasible due to very long lead times.

Last remaining solution is to cast coatings separately and to glue these to the choppers.

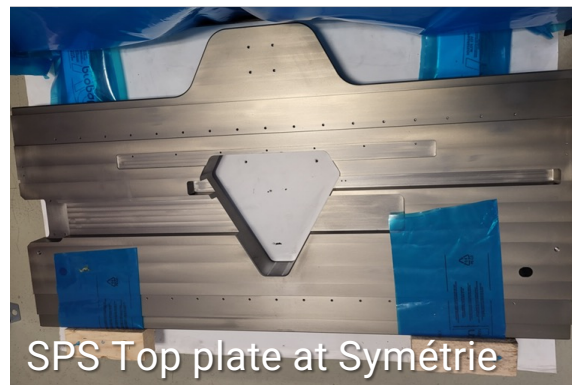


Module design is now complete and TG3.5c is scheduled in September.



Major Contracts

- NBOA (Monolith Insert) – S-DH – contract completed
- Carbon Fibre Chopper Discs – Airbus – contract completed
- Guide – Swiss Neutronics
 - Manufacture of Batch #1 in progress
 - Delivery to ESS in October
- Collimation Vessel – AVS-ES
 - Delivered to RAL
- Slits – JJ X-ray
 - Assembly in progress
- Sample Positioning System – Symétrie
 - Assembly in progress – FAT by end of this year
- In-bunker Chopper Housings – PureNetwork
 - Manufacture in progress



SPS Top plate at Symétrie



NBOA/NBPI
installed at ESS



Collimation vessel
FAT at AVS

Bunker Wall Feedthrough



The bunker wall feedthrough comprises:

- Alignment bases (STFC)

- Shielding insert (PureNetwork)

- Vacuum vessel & guide (Swiss Neutronics)



Integration tests were successfully completed at STFC during June.

The vessel is now back with Swiss Neutronics for guide integration. Delivery to ESS is planned for October.

The remaining components have been delivered to ESS.

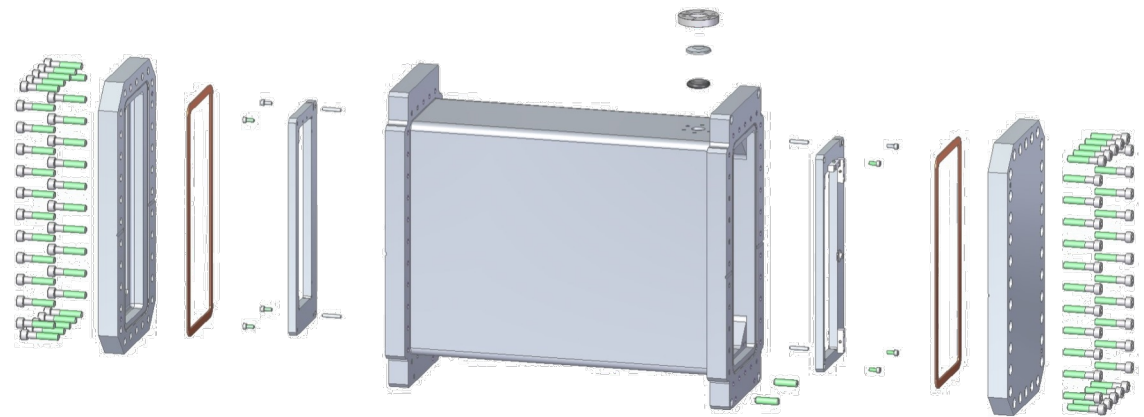


Light Shutter Optics Vessel

The light shutter vacuum housing has been cleaned and successfully vacuum tested. The highest leak rate recorded on vessel was 5.0×10^{-10} mbar l/s.

The housing has been shipped to ESS and is ready for guide integration and installation in the Autumn.

Guide delivery due in October. ESS will integrate with the light shutter mechanism.



Heavy Shutter

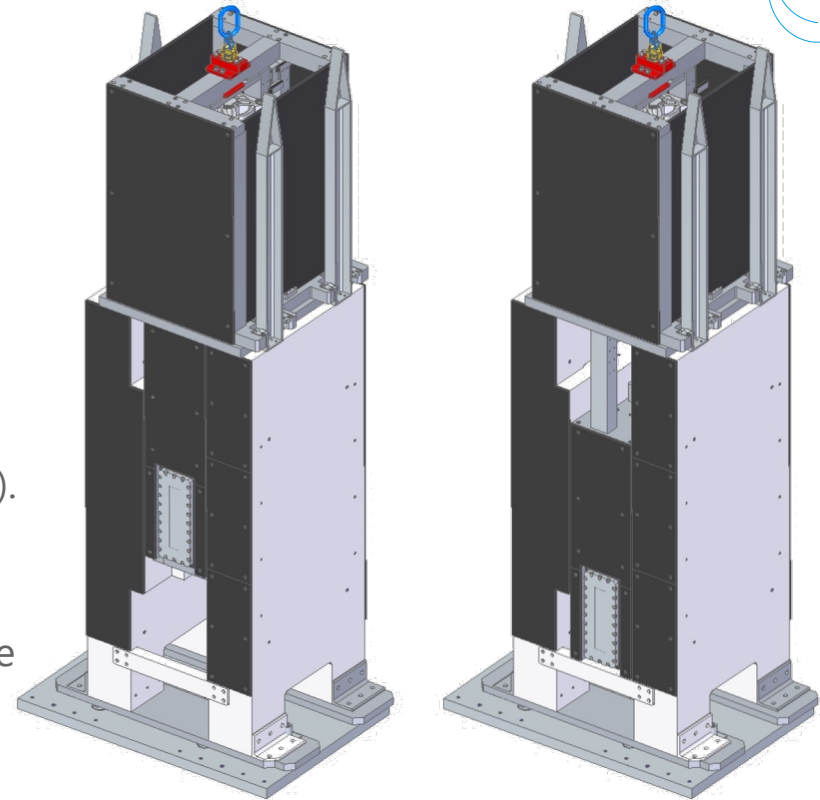
Post TG3 issues

The Sub-TG3 review was held in August, with actions outstanding.

An issue with use of flammable Polyethylene in the bunker has been identified – this derives from a recent decision to omit a sprinkler system in the bunker.

The manufacture is now on hold until this matter is resolved (originally planned to launch tenders in August).

There is a significant risk that any proposed design changes will necessitate further neutronics calculations which will impact the delivery of the shutter in time to be installed in the bunker before it is closed

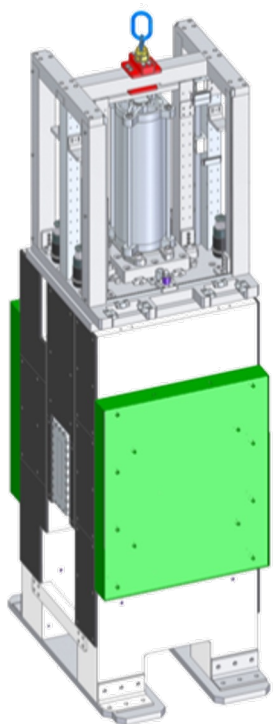


Heavy Shutter

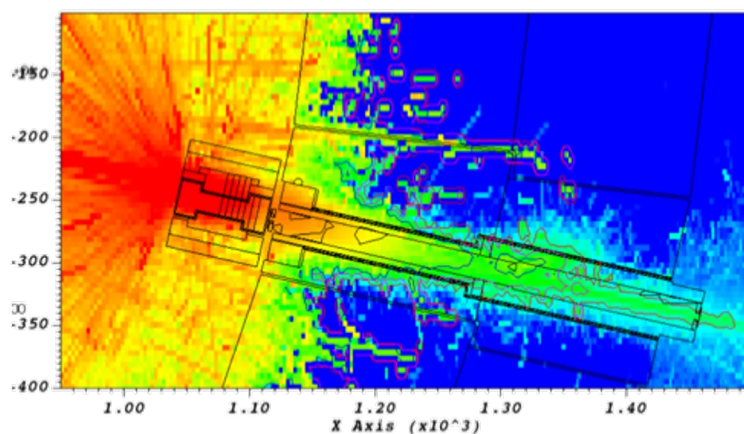
Side blocks of Polyethylene to prevent cross-talk to Loki



The fire requirements also look like they could limit the proposed Poly side panels that prevent significant cross-talk to neighbouring instruments. – likely that these will not be delivered but could be retrofitted later



Without



With

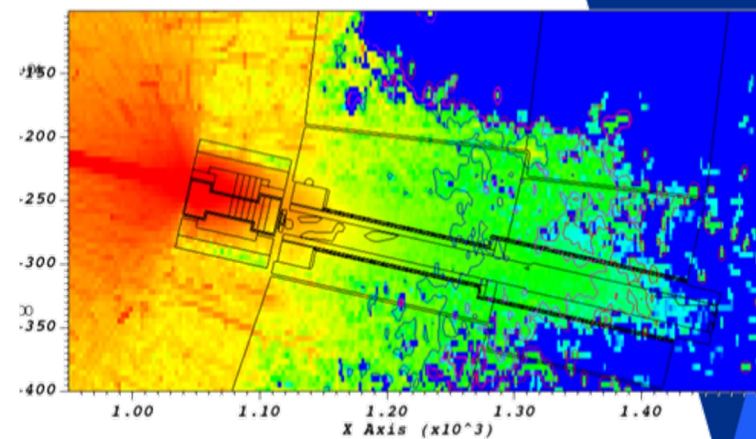


Figure 7 Neutron dose rate map closed shutter horizontal section at bunker wall opening height, high energy neutron source. (scale in $\mu\text{Sv/h}$, with contours at 100, 10 and 1.5 $\mu\text{Sv/h}$)

Note – simulation without Poly is from a previous design iteration so not directly comparable

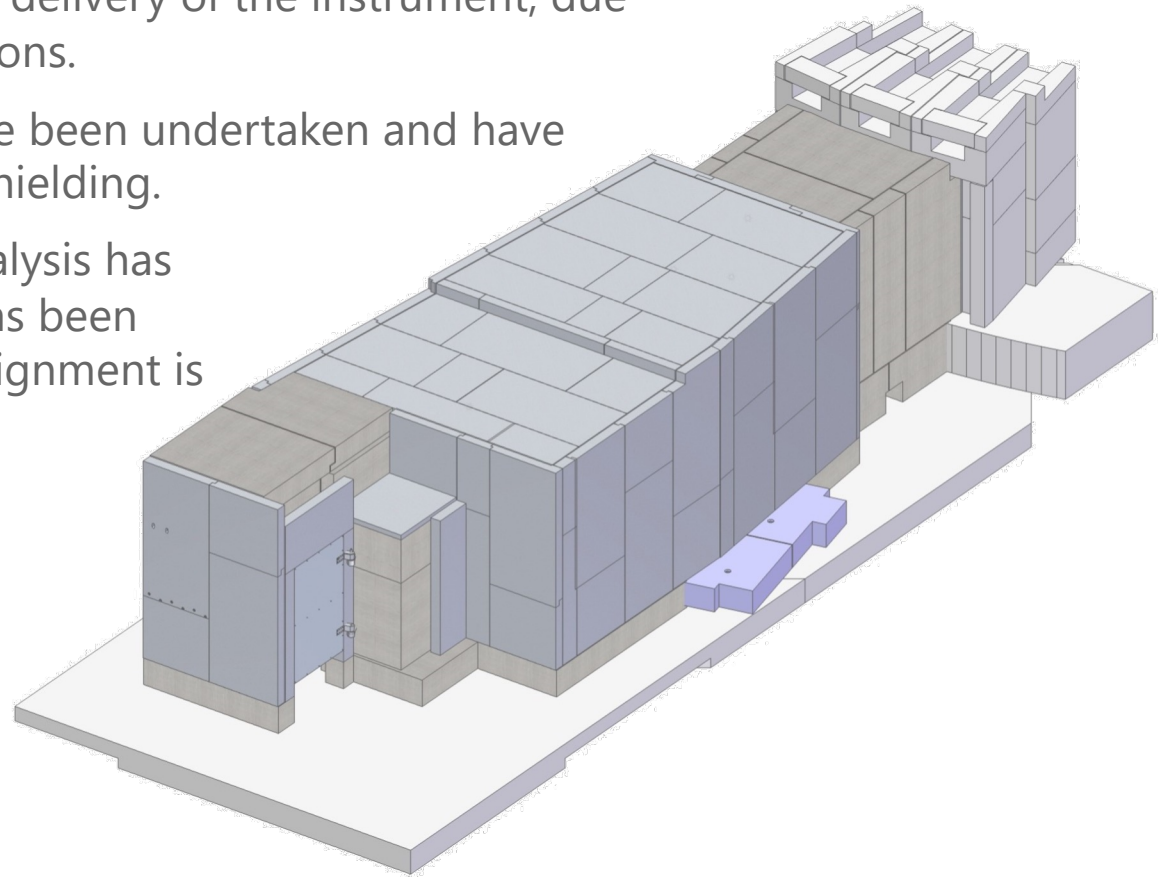
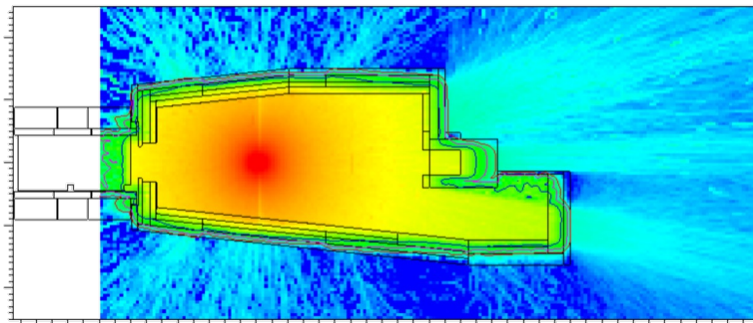
Chopper Pit & Cave Shielding



Shielding is now on the critical path for delivery of the instrument, due to previous neutronics resource limitations.

Preliminary neutronics calculations have been undertaken and have informed the general concept for the shielding.

A contract for additional neutronics analysis has been placed with UKAEA. The model has been successfully imported, and material assignment is underway ahead of the calculations.



Collimation System

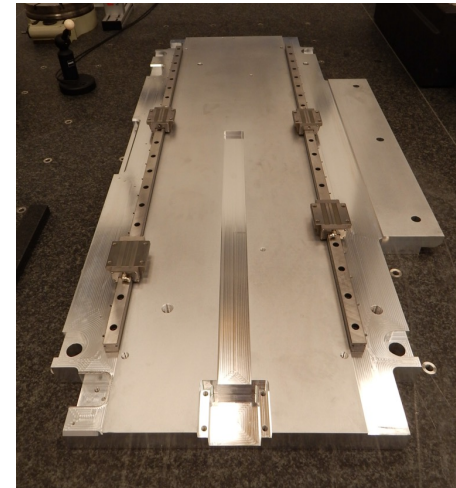
The collimation vacuum vessel has arrived at RAL and has been vacuum tested. The base supports have been delivered to R106 and are ready for pre-build.

The translation stages are currently being assembled – the rails and carriages have been installed. Further assembly of the stages is anticipated in the autumn.

Various orders for Huber motion stages have been delayed due to administrative issues – purchase orders have now been sent, and new delivery dates agreed.

The kinetics slits are out for manufacture. Mechanical components should be ready from late August. The piezo actuators are due in December.

A critical design review of the external motion system has been held, and is nearing completion.



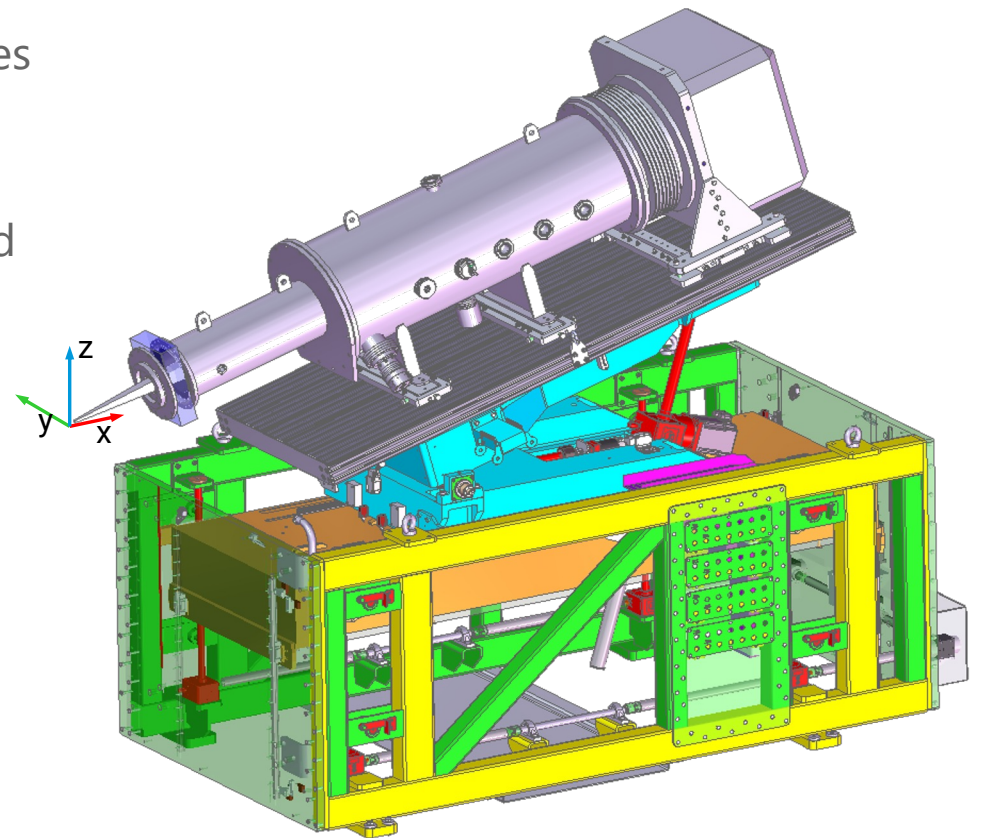
Detector Bench



The first order for manufacturing the welded frames for the detector bench has been placed, with completion due in October.

Parts have been arriving, however some orders had not been placed due to administrative issues – purchase orders have now been sent, and new delivery dates agreed. This is not likely to impact assembly of the system.

The remaining parts are out for tender.

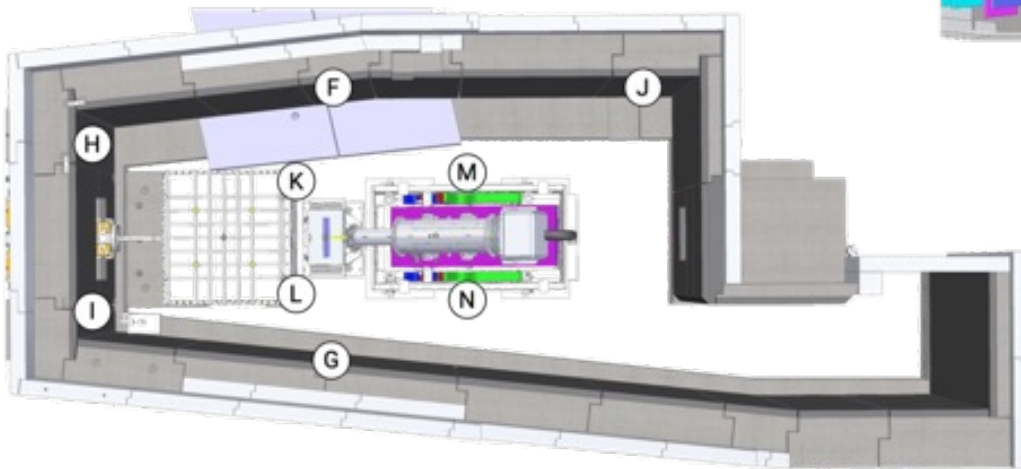


Services

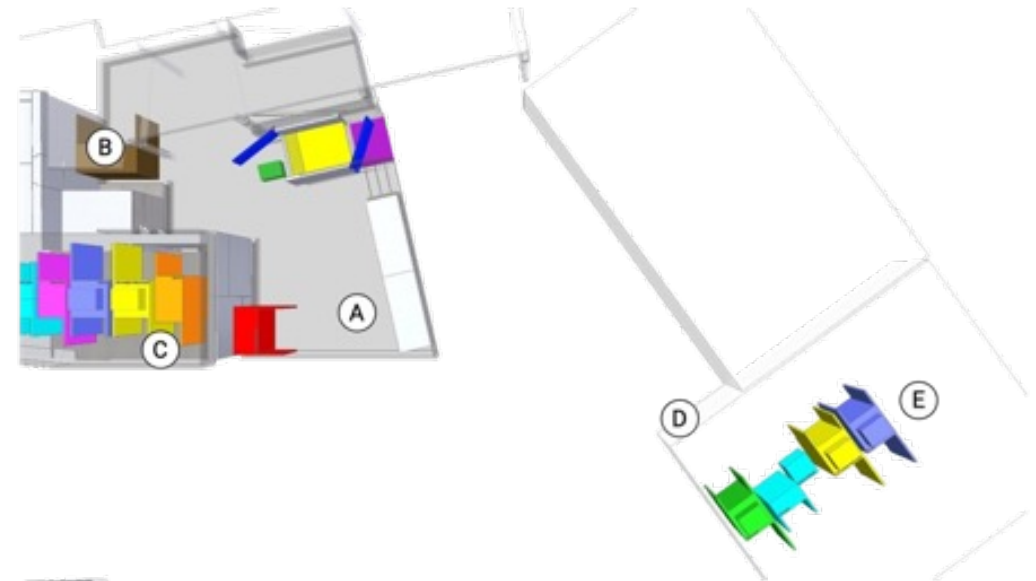


Initial steps to start the Utilities & Electrical design. In a good position to proceed... Budget should be possible this year & detailed design to begin as soon as ESS high-level prioritisation allows.

Services – Cave Internals



Services – External



Current Project Risks & Issues



Top 5 Issues

Recent developments are driving the top issues – these should reduce as mitigations are found

| Top 5 Issues | | | | | | |
|--|--------|----------|---------|------------|-------------|---|
| Title | Rating | Category | Partner | Cost | Delay | Quality |
| Shutter design cannot use Borated PE owing to NSS assessed fire hazard. Shutter redesign required with potential impact on radiation safety and scientific performance | 25 | Quality | ISIS | 25-100k€ | 7-12 months | The science case of the instrument/system is jeopardized |
| Fire safety requirements and responsibilities | 25 | Quality | ESS | 100-300k€ | 7-12 months | The science case of the instrument/system is jeopardized |
| Global supply chain issues | 20 | Cost | ISIS | 300-1000k€ | 4-6 months | N/A |
| Large chopper discs do not work | 20 | Schedule | ISIS | 100-300k€ | 7-12 months | It is probable that a high level goal can't be reached, but science case can be fulfilled |
| ESS floor capacity limit | 10 | Cost | ISIS | 25-100k€ | <1 month | N/A |

Current Project Risks & Issues

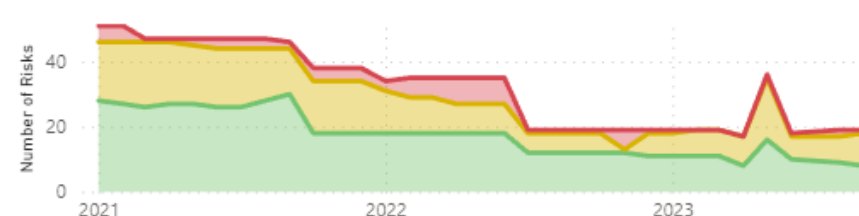


Top 5 Risks

Overall, the risk level is fairly static, with some long-standing risks that have reduced as the project progresses

| Top 5 Risks | | | | |
|---|--------|----------|---------|-----------|
| Title | Rating | Category | Partner | Treatment |
| Loss of key instrument team specialist | 16 | Schedule | ISIS | Observe |
| ESS Tollgate Delays Procurement | 12 | Schedule | ESS | Reduce |
| Delays to the ESS construction project | 12 | Schedule | ESS | Observe |
| Motion control commissioning resource unavailable | 9 | Schedule | ISIS | Reduce |
| STFC Procurement Process Delays | 6 | Cost | ISIS | Reduce |

Total Risk Trend



Risk Trend



Kinetics Slits Upgrade

A prototype developed by Uppsala University was tested with neutrons at ISIS: The paper has been published:

<https://doi.org/10.1016/j.nima.2023.168556>

A final design of the shutter system continues to be developed as part of the Uppsala collaboration, with investigations into vibration isolation and water cooling ongoing.

Conceptual solutions to these issues have been evaluated and are in detailed design.

Possibility of funding this upgrade in the short term (1-2 years) looks quite low due to ESS prioritisation of upgrades projects

